The Impact of the Special Supplemental Nutrition Program for Women, Infants, and Children on Child Health

Andrea Carlson and Ben Senauer

Data from the third National Health and Nutrition Examination Survey are used to analyze the effect of the Women, Infants, and Children (WIC) Program and other factors on the health of U.S. preschool children. Ordered probit equations are estimated for the physician's overall evaluation of the child's health. The WIC Program has a significant positive impact on the overall health of children. In particular, children in households participating in WIC are significantly more likely to be in excellent health. Increased household income also improves their health.

Key words: child health, food programs, NHANES, nutrition, WIC program.

Over one-fifth of all children in the United States live in families whose incomes are below the poverty line (Blank). The poverty rate for U.S. children is higher than for any other industrialized country. Lower incomes are linked to poor health through a variety of factors, including less access to health services and health information, plus a more limited ability to obtain acceptable and nutritious foods. One government program which addresses these problems is the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). The WIC program provides foods with specific nutrients to pregnant and lactating women, and to children up to age five in low-income households, as well as nutrition and health assessment and education. Family income must be less than 185% of the poverty level to be eligible and a health professional determine the individuals to be at nutritional risk. Persons in households who participate in certain programs such as Medicaid or Temporary Assistance for Needy Families are automatically eligible. The program had 7.2 million participants in fiscal 2000, including some 3.6 million children, at a total cost of $3.97 billion, which included $2.85 billion in food benefits and the remainder for nutrition and health services and administrative costs (U.S. Census Bureau, USDA FNS).

Several studies have examined the nutritional impact of the WIC program (Arcia, Crouch, and Kulka; Basiotis et al.; Brown and Tieman; Oliveira and Gundersen; Rose, Habicht, and Devaney; Variyam; Wilde, McNamara, and Ranney). Others have assessed specific medical outcomes, most frequently related to childbirth, infants, and pregnant women or postpartum mothers (Centers for Disease Control and Prevention; Corman, Joyce and Grossman; Devaney, Billheimer, and Schore; GAO; Hutchins et al.; Owen and Owen; Pehrsson et al.; Shefer and Massoudi). However, no analysis has yet evaluated the impact of WIC on the overall health of preschool age children, which is the focus of this study. Addressing children's health issues effectively requires a clear understanding of the underlying determinants. This study contributes to that goal by estimating a health production function for U.S. preschool children (ages 2–5 years) using data from the third National Health and Nutrition Examination Survey (NHANES III) (U.S. Department of Health, 1994). The underlying conceptual framework for this analysis is Gary Becker's household model (Becker). The health production functions obtained from this model have been widely used to study health and nutrition issues in developing countries and have received more limited use in the analysis of the health of U.S. children (Behrman and Deolalikar, Strauss and Thomas, Rosenzweig

Andrea Carlson is economist at the Center for Nutrition Policy and Promotion, USDA and Ben Senauer is professor in the Department of Applied Economics at the University of Minnesota, St. Paul, Minnesota.

The authors would like to thank the two reviewers of this Journal for their helpful comments.

Amer. J. Agr. Econ. 85(2) (May 2003): 479–491

and Schultz). This article focuses on the link between the WIC Program and the health of preschool aged children.

The National Health and Nutrition Examination Surveys (NHANES) collected by the Centers for Disease Control and Prevention provide a rich data set for analyzing factors affecting children's health. NHANES III was collected between 1988 and 1994. This nationally representative survey contains the results of a four-hour medical exam. Demographic and socioeconomic data are also included. The measure of health used in this research is the physician's overall evaluation of a child's health. The measure is a five-point scale, with one representing excellent health and five representing poor health. Because of the very few children rated in poor health, they are combined with the fair category in the analysis. Hence, there are four categories: excellent, very good, good, and fair/poor. An ordered probit model was used in the empirical analysis.

In the next section of this article, an overview of the WIC program is provided along with a brief review of some of the relevant previous research. The household and probit models are then outlined, followed by a detailed description of the data and the variables used in the research. The empirical results are then presented. Finally the work is summarized and the policy implications discussed.

Background

The WIC program is administered by United States Department of Agriculture's Food and Nutrition Service. In most cases, WIC recipients receive monthly vouchers or checks used to purchase a food package designed to supplement their diet. In a few locations, other distribution systems are still used, such as directly providing the food package at the health clinic. WIC is meant to only supplement the diet and does not cover the total nutritional needs of participants. The nutrition education provided under the program provides guidance on obtaining a balanced diet with all the necessary nutrients.

WIC focuses on nutrients which have been food deficient in the diet of the target population—protein, calcium, iron, and vitamins A and C. The foods in the WIC package also provide vitamins D and B-6 and folate. The types and amounts of foods in the WIC package are based on the age and nutrient needs of the individual. Milk and/or cheese, iron-fortified cereal, 100% fruit and/or vegetable juices, eggs, peanut butter, and/or beans/peas are typically included in the food package for children. The average cost of the WIC food package per month was $31.20 in 1996 and $34.31 in 2002 (USDA FNS, Oliveira and Gunderson). The WIC package for children is given to children ages 1 to 5, but is based on USDA/DHHS dietary recommendations for children ages 2 to 6.

Adult WIC recipients must participate in two nutrition education sessions in the typical six month certification period. Recipients also are referred to other social and health care services, such as immunizations. WIC is not an entitlement and especially in its early years, sufficient funding was not allocated by Congress to cover all those eligible. When funds have been inadequate, local WIC agencies use a system that gives priority to those with nutritional deficiencies that have evident medical consequences and to pregnant and breast-feeding women and infants, before children (Oliveira and Gunderson).

Evaluations have found clear evidence of the beneficial impacts of the WIC program. A General Accounting Office (GAO) study found prenatal WIC benefits reduced low birthweights by 25% and very low weights by 44%. This GAO report concluded that each one dollar spent on prenatal WIC reduced public and private spending on health care by a discounted present value of $3.50, with most of the savings ($2.89) in the first year of the baby's life (GAO). Such evidence of the positive impact of WIC has led to increased funding by Congress from $728 million in 1980 to $2.12 billion in 1990. Congress allocated $4.39 billion in fiscal year 2002 to the program (USDA, FNS). Children have been the most rapidly increasing group of WIC recipients. Total participation rose 63% from 1990 to 1998, whereas the number of children participating grew by 81%. Consequently, more children at risk are being covered. It was estimated that 69% of children eligible for WIC participated in 1996 (Oliveira and Gunderson). By 2002 about 81% of eligible children were being served (FNS).

In terms of nutrition, WIC had a positive impact on all components of the U.S. Department of Agriculture's Healthy Eating Index except saturated fat (Basiotis, Kramer-LeBlanc, and Kennedy).[1] At least two studies found that WIC children were less

[1] The Healthy Eating Index provides a guide to how well the diet matches dietary recommendations. The 100-point index is divided

likely to have a low iron intake than non-WIC participants of similar income (Brown and Tieman, Oliveira and Gundersen). Iron deficiency is linked to behavioral and developmental delays in children (U.S. Department of Health, 1998). WIC participants had higher intakes of Vitamins C, A, B-6, and folate (Oliveira and Gundersen) and grains, fruit, dairy, and meat (Basiotis et al.). WIC participants had a lower intake of added sugars (Wilde, McNamara, and Ranney), total fat, cholesterol, and sodium (Basiotis et al.). Rose, Habicht, and Devaney also found WIC participation increased the consumption of ten nutrients.

Variyam used quantile regression to assess the effect of WIC on eligible preschool children and found that evaluation at just the conditional mean can be deceiving. He discovered that the impact of WIC varied considerably by quantile for iron and zinc. For calcium the effects were basically equal across quantile, but even for this nutrient there was variation in the impacts across quantiles of other important variables such as age and gender. Arcia, Crouch, and Kulka found WIC participants purchased more nutritious food, more nutrient-dense food and spent less on food away from home.

In terms of medical outcomes, infants born to mothers who participate in WIC have higher birthweights and the prevalence of low and very low birthweight is lower than for eligible nonparticipants (Buescher et al., Owen and Owen). In addition, the incidence of iron-deficient anemia is lower among toddlers, preschool children, and postpartum women in the WIC program (Owen and Owen, Pehrsson et al.). Prenatal WIC participation was associated with significant Medicaid savings in the first 60 days after birth, ranging from \$277 to \$598 depending on the state (Devaney, Billheimer, and Schore). Another study found that the mother's participation in WIC before and after birth reduced neonatal mortality (Corman, Joyce, and Grossman). A report in the CDC's Morbidity and Mortality Weekly Report finds that while obesity remains a severe public health problem, WIC participating children are no more likely to be over weight than other low-income children (U.S. Department of Health, 1996). Finally, at least two studies have found that WIC participation can improve child immunization rates, if the WIC program office continually assesses participant's immunization records and makes the appropriate referrals (Hutchins et al., Shefer and Massoudi).

In sum, the previous research on the WIC program focused on improved nutrition intake and specific medical outcomes such as increased immunization rates and a reduction in iron-deficient anemia. While a healthier diet and increased immunization rates should result in better health for children, no one that we know of has examined the program's effect on the overall health of children.

The Model

Health production and demand functions have been widely used in economics to study children's health in developing countries (Behrman and Deolalikar, Strauss and Thomas). More limited use has been made of the household production model to analyze determinants of child health and diet quality in the United States. One analysis which did use this model found that mother's health and nutrition knowledge were significant in child's diet quality (Variyam, Blaylock, and Lin). Another household production analysis concluded that delays in the mother seeking prenatal care, as well as smoking or alcohol consumption during pregnancy, contributed to low birthweights, which are often associated with poor health in infants (Rosenzweig and Schultz).

Based on Becker's model, the household is assumed to maximize utility in terms of the family members' health, consumption of other household produced goods and services, and leisure. The health production function for the ith child's health (H_i) can be specified as

$$(1) \qquad H_i = h(I_i, C_i, F_i, G_i)$$

where I_i is a vector of inputs to health such as food consumption and medical care, C_i is a vector of characteristics of the child such as the child's age and gender, F_i is a vector of household characteristics such as the parents' education, and G_i is a vector of community and/or geographic characteristics such as region of the country. The maximization of utility subject to time and income constraints yields reduced-form health demand functions, which contain only exogenous explanatory factors (Behrman and Deolalikar, Senauer and Garcia).

into ten components: grains, fruits, vegetables, milk, meat and meat substitutes, total fat, saturated fat, cholesterol, sodium, and variety. Each component receives a maximum of ten points.

This study estimates a health production function. Some household characteristics such as participation in the WIC and Food Stamp Programs may be jointly determined with health. WIC gives preference to children who are at nutritional risk or have certain health conditions. Similarly, parents may make a greater effort to apply for WIC or food stamps if their child is not healthy. These variables should be tested for endogeneity, since the estimates may be biased due to simultaneity and unobserved heterogeneity.

The health production function can be specified as

$$(2)\qquad H_i^* = \beta'\mathbf{x} + \varepsilon$$

where H_i^* is the child's actual health, $\mathbf{x}$ is a vector of explanatory variables, β' is the vector of coefficients, and ε is the error term. Although actual health is a continuous variable, what is observed is the physician's evaluation into five categories,

$$(3)\qquad \begin{array}{lll} H = 0 & \text{Excellent} & \text{if } H^* \leq \mu_0 \\ H = 1 & \text{Very Good} & \text{if } \mu_0 < H^* \leq \mu_1 \\ H = 2 & \text{Good} & \text{if } \mu_1 < H^* \leq \mu_2 \\ H = 3 & \text{Fair/Poor} & \text{if } \mu_2 < H^*, \end{array}$$

where H is the observed health and the μ_j's are cut-off values for health. Note that if health were plotted on a horizontal axis, more health would be to the left, and less health to the right.

Thus, the physician rates the child in "excellent" health ($H = 0$) if the child's actual health, H^* is below μ_0, in "very good health" ($H = 1$) if the child's actual health falls between μ_0 and μ_1 and so on. The cut-off points are estimated by the model. In order to preserve the order of the H's, it must be that

$$(4)\qquad \mu_0 < \mu_1 < \mu_2 .$$

Greene describes the ordered probit model in detail. Assume that the error terms are normally distributed across observations and can be normalized such that they have a mean of zero, and a variance of one. The probability that H (measured health) will equal 0, 1, 2, or 3 is given by

$$(5)\qquad \begin{aligned} \text{Prob}[H = 0] &= \Phi(\mu_0 - \beta' x) \\ \text{Prob}[H = 1] &= \Phi(\mu_1 - \beta' x) \\ &\quad - \Phi(\mu_0 - \beta' x) \\ \text{Prob}[H = 2] &= \Phi(\mu_2 - \beta' x) \\ &\quad - \Phi(\mu_1 - \beta' x) \\ \text{Prob}[H = 3] &= 1 - \Phi(\mu_2 - \beta' x) \end{aligned}$$

where Φ is the cumulative standard normal distribution. The maximum likelihood method can be used to find values for β and the μ's. This method uses the maximum likelihood principle that the best explanation of a set of data is the one which maximizes the likelihood function.

The parameters in β reflect the effect of changes in $\mathbf{x}$ on the probability of the child being in excellent health. Maximum likelihood was used to estimate the ordered probit model (Stata Corporation).

Marginal Effects

A drawback to the ordered probit model is that the estimated parameters are difficult to interpret. Greene demonstrates that one way to understand the parameters is to calculate the marginal effect of a change in a continuous explanatory variable on the probability of being in each category. That is, calculate the first derivative of equation (5) for each $\boldsymbol{x}$. The marginal estimates are given by

$$(6)\qquad \begin{aligned} \frac{\partial(\text{Prob}[H = 0])}{\partial x} &= -\varphi(\mu_0 - \beta' x)\beta \\ \frac{\partial(\text{Prob}[H = 1])}{\partial x} &= -\varphi(\mu_1 - \beta' x)\beta \\ &\quad + \varphi(\mu_0 - \beta' x)\beta \\ \frac{\partial(\text{Prob}[H = 2])}{\partial x} &= -\varphi(\mu_2 - \beta' x)\beta \\ &\quad + \varphi(\mu_1 - \beta' x)\beta \\ \frac{\partial(\text{Prob}[H = 3])}{\partial x} &= \varphi(\mu_2 - \beta' x)\beta \end{aligned}$$

where φ is the probability density function for the standard normal. The maximum likelihood calculations of β were calculated using STATA version 7, while marginal effects for continuous variables were calculated using equation (6) in Excel 2000.

For binary predictor variables, the first derivative result does not apply. In order to study the effect of a binary variable, Greene suggests calculating the difference in probabilities when the equation is evaluated at both levels of the binary variable with other explanatory variables at their mean values. Therefore, the marginal effect of a binary variable is

$$(7)\qquad \begin{aligned} &\text{Prob}(y = 1 \mid \bar{x}_*, b = 1) \\ &\quad - \text{Prob}(y = 1 \mid \bar{x}_*, b = 0) \end{aligned}$$

where $\bar{x}_*$ equals the mean of all the other variables and b is the binary explanatory variable. For example, the probability of being in excellent health can be calculated for WIC participants and nonparticipants, with all other inputs held at their mean value. The marginal change due to WIC is then the difference between the two probabilities.

Data and Variables

The third National Health and Nutrition Examination Survey (NHANES III) is the most recent complete set of data in a series of studies designed to collect information on the health status of the population of the United States; the National Institutes of Health began collecting national health information in 1960. Since the NHANES III data were used to update and correct the growth charts of children ages two months to five years, this group was oversampled. In order to examine risk factors associated with health in African-Americans and Mexican-Americans, these groups were also oversampled.

The Centers for Disease Control and Prevention collected the NHANES III between 1988–94. Survey workers collected demographic data and information on general health, use of health services, and housing characteristics in an interview in the home. Nearly three-quarters of the participants also received a four-hour medical exam at a mobile Medical Exam Center (MEC). The MECs, including the twelve physicians and other persons involved with the exams, moved from city to city, preserving consistency in the medical exam. The survey included many tools to induce those selected for the study to participate, especially those selected for the medical exam portion of the survey. Participants in the medical exam received \$30 and the possibility of an additional \$20 depending on the nature of the exam and the participant's required fasting schedule. In addition, the survey staff were specially trained to convince participants to both be interviewed and to receive a medical exam. In the end, 77% of those who originally made appointments at a MEC, received medical exams at a center (U.S. Department of Health, 1994).

Within area segments selected for the survey, interviewers screened 93,653 households to identify participants for the study. Based on the screening data, survey designers selected 40,600 sample persons from those households. The survey interviewed 33,994 persons and examined 30,818 persons in the mobile exam (U.S. DHHS). A total of 3,104 kids ages 24 to 60 months (including 24 and 60 months) actually received medical exams by a doctor.[2] A number of these observations had to be excluded from the empirical analysis because of missing values for one or more of the variables. In order to avoid intrafamily correlation, we randomly selected one child from each family, if there was more than one child ages 2 to 5 years old. Sample weighting only controlled for age, gender, race, and ethnicity, and did not include intrafamily conditions which might affect health. This brought the total down to 2,632 observations, which is referred to as the "full" sample in the analysis.

Previous studies of child health have tended to focus on either infants up to two years old or preschoolers, ages 2–5 years (Behrman and Deolalikar, Senauer and Garcia). The relationship between health determinants and outcomes is likely quite different for these two groups. Therefore, this study is restricted to children ages 24–60 months old.

A special sample of children who live in households which are believed to be eligible for WIC was also developed. In this case, a household was considered eligible for WIC if the household income was less than or equal to 185% of poverty or someone in the household qualified for Medicaid (Kramer-LeBlanc et al.). The total number of children in this sample, after missing variables and multiple child families were accounted for, was 1,816 children. This is referred to as the "WIC eligible" sample. The sample weights for subjects with a medical exam were used in this study. Weights were provided so that the sample would be more nearly representative of the U.S. population, and WIC eligible population.

Variables

Dependent Variable

According to the medical community, one measure of health is the physician's overall evaluation (Wolfe and Sears). This measurement generally ranks an individual's health on a 1 to 5 or 1 to 10 scale. The doctor's evaluation takes into account the child's height and

[2] There are actually 3,594 children whose age at the time of the MEC exam was between 24 and 60 months, including the end points. However, not all of these children were examined by a doctor, and thus had an evaluation of overall health status.

weight, and other indicators of health such as disease and illness history, and the results of a medical examination. "The American Children: Key National Indicators of Well-Being 2001," produced by the Federal Interagency Forum on Child and Family Statistics lists the physician's evaluation as the first measure of general health status for children (Federal Interagency Forum on Child and Family Statistics). Other studies in the health literature also use this variable as a measure of overall health (Alaimo, Olson, and Frongillo).

The dependent or response variable is the physician's overall evaluation of the child's health. In the survey the physicians were not the children's regular doctor, but moved with the MECs. Throughout the six years of data collection, only twelve different doctors saw all participants which helped to create a highly standardized evaluation. The physicians based their evaluation on the comprehensive medical exam before the lab results were complete. They rated the children at one of five levels: excellent, very good, good, fair, and poor. Because so few children were rated in poor health, that category was combined with fair, so that the analysis is conducted for four levels of health (see table 1).

Explanatory Variables

As discussed above, the explanatory variables are divided into characteristics of the child, household, and geographic location. The explanatory variable of most interest is whether the household participated in the WIC program. We chose whether anyone in the household was participating, rather than just the child, because household food is generally shared between family members. In addition, WIC coupons may free up money in the family's food budget for other members to consume. A recent analysis of the nutritional status of WIC participants found that some pregnant women did not consume all the nutrients provided to them in their WIC basket (Kramer-LeBlanc et al.). This might be an indication that they are sharing food with other members of the family; it might also mean the household is not purchasing the food with the coupons provided.

As mentioned above, WIC is not an entitlement program, and preference is given to children who have certain health conditions or are considered nutritionally at risk. Thus, WIC participation may be jointly determined with health. Similarly, if parents believe their children are less healthy than other children, they may be more likely to apply for the Food Stamp Program. Although the Food Stamps Program is an entitlement program, people who choose to participate are more likely to believe they will have a low income for a longer period of time than others with similar incomes who do not participate (Blank and Ruggles). Since WIC and Food Stamp Program participation may be jointly determined with child health, these variables should be tested for endogeneity using the Hausman test.

Because of the way the data were collected, the food stamp variable measured whether anyone in the household participated in the last twelve months, and the WIC variable measured whether anyone in the household participated in the last month. Since food stamps and WIC may increase food consumption and improve nutrition, participation was expected to have a positive impact on health.

Other household characteristics which might be expected to affect child health include income and how crowded the house is. The poverty income ratio (PIR) rather than household income is provided in the NHANES data. The PIR is a measure of the family's income divided by the federal poverty line for that household's composition. If the PIR is less than one, the family is below the federal poverty line. PIR reflects the standard of living which the family is able to afford, since family size is already accounted

Table 1. Distribution of Health Categories

	WIC Eligible Sample		
Health Categories	WIC Participant (%)	WIC Nonparticipant (%)	Full Sample (%)
1—Excellent	79.43	77.33	80.37
2—Very Good	8.87	9.86	8.84
3—Good	11.09	11.90	10.33
4—Fair/Poor	0.60	0.92	0.45
Sample size	673	1,143	2,632

for by the poverty line. Separate information on nonlabor or unearned income and adult wages were not collected in the survey. As in other studies, a higher PIR is expected to lead to better health. Crowding can affect a household in a number of ways. First, children who share a bedroom with another person may be more exposed to respiratory infections. Second, children with more space have more opportunities to participate in active play without disturbing the adults in the household. We define crowding as the number of persons in the household divided by the number of rooms. This number includes unrelated household members such as boarders or families who share living space. It is expected that the more people per room, the less healthy the child.

Finally, the household characteristics include a set of variables which attempt to measure the parents' ability to provide a healthy environment. Unfortunately, the data set only included information for the adult who answered the survey questions. This study assumed the interviewee was the child's primary caretaker. In 90.1% of the cases, this person was the child's mother, and in 5.4% of the cases the child's father. The remaining 4.56% of the cases were divided between grandparents (2.7%), aunts and uncles (0.65%), other person (0.55%), and unknown (0.55%). The variables included for the parent or other caretaker are the person's education level, whether they speak English at home, whether he/she is currently married, and if not currently, then was the adult married before.

The child's characteristics include how many days the child was breast-fed after birth, whether the child's birthweight was less than 2,500 g, the child's race and ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and other), and the age and sex of the child. The medical literature suggests that breast-fed babies have fewer ear infections, cases of diarrhea, and lower respiratory infections during lactation (Ball and Wright, Beaudry, Dufour, Marcoux, Cushing et al.). The beneficial health effects may continue when they are older. Low birthweight infants have more health problems, some of which may continue into preschool age.

Regions of the country (Northeast, South, Midwest, and West) are included in two of the models. In the other two models presented in the next section, a set of binary variables representing forty-nine pseudo strata from the survey are used instead of the regions. Children in the same pseudo strata are located in the same county. Public health clinics are administered at the county level, so a variable which distinguishes between counties may be predictive of health. In addition, persons in the same pseudo strata or county are likely to be exposed to many similar environmental and socioeconomic factors not included as specific explanatory variables, which could affect health, such as levels of pollution. This variable might also capture differences in the administration of the WIC program across counties.

This study also considered several interaction variables such as WIC participation and PIR, employment status of the adult and PIR, and marital status and employment status of the adult. None of these were significant, and hence they are not reported in the empirical results.

A detailed description and summary statistics for each variable used in the final model in both the WIC-eligible and full samples are listed in table 2. As one might expect, the WIC eligible sample contains twice as many WIC and Food Stamp Program participants as the full sample. It should be noted that our measure of WIC eligibility is not perfect, since we did not have information on assets; it is likely the WIC sample contains children who live in households which are not actually eligible for WIC. The PIR is twice as high in the full sample as in the WIC eligible sample. As might be expected from the differences in income, the number of persons per room is higher in the WIC eligible sample, while the percent of parents who are married is lower. The number of days the child was breastfed as an infant is also lower in the WIC eligible sample, and the percent of low birthweight children is higher. Both the percent of children who are female and the distribution between the regions of the country are similar in both samples.

Empirical Results

The results of using the ordered probit model to estimate the health production function are presented here. Four equations or models were estimated with the two samples and regions or pseudo strata. As mentioned above, there are theoretical reasons why WIC and food stamp participation might be endogenous. Greene recommends using a Hausman test as the first step to check for endogeneity. Variables used for identification in making this test included adult employment, urbanization,

Table 2. Definitions and Means/Frequencies for Explanatory Variables

Variable	WIC Eligible Sample	Full Sample
Child is female (=1; 0 otherwise)	0.483	0.481
Child is non-Hispanic White (omitted in regression) (=1; 0 otherwise)	0.494	0.634
Child is Hispanic (any race) (=1; 0 otherwise)	0.228	0.163
Child is non-Hispanic, Black (=1; 0 otherwise)	0.232	0.154
Other race: Not White, Black, or Hispanic (=1; 0 otherwise)	0.046	0.049
Age at the MEC exam (in months)	41.659	41.756
Number of days breastfed	76.815	100.952
Child's birth weight < 2500 g (=1; 0 otherwise)	0.129	0.106
Household participated in WIC (=1; 0 otherwise)	0.319	0.171
Household participated in Food Stamp Program (=1; 0 otherwise)	0.480	0.244
Poverty income ratio: Household income divided by poverty level	1.011	2.174
Years of education of parent	11.167	12.433
Parent speaks English at home (=1; 0 otherwise)	0.790	0.846
Parent married now (=1; 0 otherwise)	0.620	0.778
Parent married before but not now (=1; 0 otherwise)	0.203	0.133
Crowding (number of persons divided by number of rooms)	0.975	0.821
Midwest	0.219	0.222
South	0.371	0.351
West	0.244	0.245
Northeast (omitted) (=1; 0 otherwise)	0.166	0.182
Sample size	1,816	2,632

the mother was 18 years or less at the time of the child's birth, percent of the child's life on WIC, whether the child and parents were born in the United States, whether the parents speak English in the home, the length of time the family has lived at the address and the child has lived in the city, and phase of the survey (Phase I: 1988–91; Phase II: 1992–94). The last variable was included as a proxy for year, since year is not included in the data set. These variables had particularly low *t*-statistics when used to predict the children's health status.

The Hausman test showed that WIC and Food Stamp Program participation are not endogenous variables. The Wald statistic is −0.81, which when compared to a $\chi^2(17)$ we accept the null hypothesis that WIC and Food Stamp Program participation are exogenous. Note that the Hausman test is very dependent on the availability of good instruments. The first-stage equations correctly predicted WIC participation for 80% of children in the full sample, and Food Stamp Program participation for 84% of children, which would seem to indicate reasonable instruments.

Estimated Health Equations

Results are presented in table 3 for four ordered probit equations, where child health is the dependent variable in all four cases. Models 1 and 2 use the WIC eligible sample, while models 3 and 4 use only the full sample. Models 1 and 3 include regions, while Models 2 and 4 use the binary variables for the pseudo strata, instead of the regional variables. The coefficients of the pseudo strata are withheld to save space. These results control for the complex sample design of NHANES in two ways. In models 1 and 3, where the regions are used, we used STATA's svyoprobit command to make the estimations, using the pseudo strata and pseudo primary sampling units (PSU) as suggested in the survey's documentation. In models 2 and 4, the pseudo strata are already included in the model, thus it does not make sense to use the svyoprobit command. Instead we used the regular ordered probit procedure. While this does not account for the survey strata, it is a close approximation of the svyoprobit. The svyoprobit command only produces an overall F-test, while the ordered probit command gives the usual chi-squared test of significance. All four statistics show that the models are statistically significant at a high level. Only the statistically significant variables in the four equations will be discussed. WIC participation is significant in all four models.

With the WIC eligible sample in model 1, the statistically significant variables include low

Table 3. Estimated Health Equations

Variables	WIC Eligible Sample (1) Regions	WIC Eligible Sample (2) PSUs	Full Sample (3) Regions	Full Sample (4) PSUs
Female	−0.072	−0.087	−0.162	−0.240
	(0.70)	(0.79)	(2.03)**	(2.74)***
Hispanic	0.163	0.061	0.0005	0.124
	(0.832)	(0.28)	(0.00)	(0.70)
Non-Hispanic Black	−0.280	−0.452	−0.078	0.183
	(1.56)	(2.73)***	(0.50)	(1.40)
Other race	0.335	0.368	−0.147	−0.115
	(0.95)	(1.05)	(0.55)	(0.35)
Child's age	−0.001	0.0005	−0.004	−0.007
	(0.27)	(0.10)	(1.64)	(1.89)*
Days breastfed	−0.0005	−0.0003	−0.0002	−0.0001
	(1.05)	(0.70)	(0.60)	(0.36)
Birthweight < 2500 g	0.359	0.539	0.089	0.226
	(2.54)***	(2.81)***	(0.68)	(1.33)
WIC	−0.243	−0.346	−0.199	−0.302
	(2.65)***	(2.82)***	(2.03)**	(2.36)**
Food stamps	−0.156	−0.174	−0.209	−0.118
	(1.39)	(1.31)	(1.75)*	(0.93)
Poverty income ratio	−0.236	−0.305	−0.175	−0.155
	(1.83)*	(1.82)*	(3.96)***	(3.09)***
Parent's education	−0.023	−0.024	−0.004	0.0007
	(1.41)	(1.15)	(0.20)	(0.04)
Parent speaks English at home	0.427	0.288	0.037	0.015
	(1.94)*	(1.56)	(0.21)	(0.08)
Parent married now	−0.017	−0.172	−0.058	−0.203
	(0.12)	(0.99)	(0.51)	(1.22)
Parent married before	−0.110	−0.141	0.039	−0.001
	(0.68)	(0.77)	(0.30)	(0.01)
Crowding	0.015	−0.023	0.025	0.030
	(0.13)	(0.22)	(0.21)	(0.28)
Midwest	−0.498	—	−0.677	—
	(1.68)*		(2.38)**	
South	−0.895	—	−1.09	—
	(3.26)***		(4.17)***	
West	−1.10	—	−1.18	—
	(3.75)***		(4.66)***	
F-statistic	2.87	—	8.08	—
Chi-squared	—	10,811	—	959

Note: *t*-statistics are given in parentheses; * significant at $p = 0.10$; ** significant at $p = 0.05$; *** significant at $p = 0.01$.

birth weight, participation in WIC, the parent speaks English in the home, the poverty income ratio, as well as the three regions (Northeast is omitted). WIC, the PIR, and the three regions have a positive effect on child health, while children who were less than 2,500 g at birth or whose parent does not speak English in the home, are negatively affected by these factors. In model 2 where pseudo strata replace regions, non-Hispanic Black, birthweight, WIC, and the poverty income ratio are significant. Being a non-Hispanic Black, WIC participant and higher household income relative to the poverty level have a positive effect, whereas a low birth weight has a negative effect. A number of the pseudo strata variables were also significant, reflecting the importance of a wide range of possible location related factors, which might include local differences in the administration of the WIC program.

In model 3 with the full sample and regions, the child's gender, WIC and Food Stamp Program participation, the poverty income ratio and the three regions have positive and statistically significant effects on the child's health. If the child is a girl, in a household that participates in WIC and receives food stamps, household income is higher in relation to the poverty level or in one of the three regions other than the Northeast, she is likely to be in better overall health. In model 4 with pseudo strata replacing the regions, the significant variables include gender, the child's age, WIC, and the poverty income ratio and each has a positive effect on child health.

The robust nature of the WIC results stand out, with the program having a strongly significant positive effect on child health in all four models. The only other variable which is significant in all four equations is the household's income in relation to the poverty level. The regional variables are strongly significant in the equations in which they are included, as are most of the binary variables for pseudo strata.

Marginal Probabilities

The marginal effects are given for the key variables found to be significant in table 4. The marginal probabilities for the continuous variables can be interpreted as the increased or decreased probability the child would have been in the health category (excellent, very good, good, and fair/poor), given one more unit of the explanatory variable, with other variables held at their mean. For the binary variables, the interpretation is the increase (or decrease) in probability if the binary variable is true. For example the marginal value for excellent health for WIC in model 1 is 0.065. This means if the household participates in the WIC program, the probability of the child being in excellent health will rise by 6.5 percentage points. For continuous variables, the estimates are the partial derivatives as calculated using equation (6). The marginal change for binary variables is calculated using equation (7).

Participation in the WIC program increases the probability that the child is in excellent health by 4.6 to 11.4 percentage points depending on the model. Thus if a child not enrolled in WIC has a 75% chance of being in excellent health, participation in the WIC program will raise this to a 80 to 86% chance of being in

Table 4. Marginal Probabilities for Significant Variables

	Health Categories			
	Excellent	Very Good	Good	Fair/Poor
Model 1. WIC sample-regions				
Birthweight < 2500 g	−0.110	0.037	0.066	0.007
WIC	0.065	−0.025	−0.037	−0.003
Poverty income ratio	0.066	−0.025	−0.038	−0.003
Parent speaks English	−0.106	0.043	0.059	0.004
Midwest	0.122	−0.050	−0.067	−0.005
South	0.224	−0.086	−0.126	−0.011
West	0.234	−0.097	−0.127	−0.010
Model 2. WIC sample-PSUs				
Non-Hispanic Black	0.153	0.026	−0.131	−0.047
Birthweight < 2500 g	−0.145	−0.060	0.115	0.090
WIC	0.114	0.024	−0.098	−0.040
Poverty income ratio	0.096	0.025	−0.083	−0.038
Model 3. Full sample-regions				
Female	0.040	−0.016	−0.022	−0.001
WIC	0.046	−0.019	−0.025	−0.001
Food stamps	0.049	−0.020	−0.027	−0.001
Poverty income ratio	0.043	−0.018	−0.024	−0.001
Midwest	0.138	−0.061	−0.074	−0.003
South	0.231	−0.096	−0.128	−0.006
West	0.215	−0.095	−0.114	−0.005
Model 4. Full sample-PSUs				
Female	0.044	−0.028	−0.016	−0.0001
Age	0.001	−0.0008	−0.0005	−0.000004
WIC	0.049	−0.032	−0.017	−0.0001
Poverty income ratio	0.029	−0.018	−0.011	−0.00009

excellent health. Higher marginal values were found in the WIC eligible sample, indicating that poor children benefit more from the program. However, the strong effect in the full sample shows that even if poor children are compared to the rest of the population, they still fare better if they participate in WIC. The sum of marginal probabilities across the four health categories should net out to zero (with possible exceptions due to rounding numbers off). Just as a child participating in WIC is more likely to be in excellent health, he/she is less likely to be in the other three categories, except for model 2 in which the probability of being in good health is also higher.

Note that the marginal value for the poverty income ratio (2.9 to 9.6 percentage points) is actually quite small. A rise from a PIR of 1 to 2 (by one unit) means going from 100% of the poverty line to 200%; for a family of four the rise in 1999 was equivalent to a shift in income from $17,029 to $34,058 (U.S. Census Bureau). The WIC program is apparently much more effective at improving child health than even large increases in household income. In only one case (model 3) do food stamps significantly affect child health, raising the likelihood of being in excellent health 4.9 percentage points.

There is a substantial regional impact on child health, with children living outside the Northeast having a higher probability of being in excellent health by 12.2 to 23.4 percentage points. The pseudo strata in the Northeast also tended to have a negative impact. This result is not confirmed by other studies, and may be unique to this data set. One factor which affects the health of children in this age group is lead poisoning. The Northeast has a higher incidence of lead poisoning among children due to the higher concentration of older buildings with lead paint. According to unpublished data from the Centers for Disease Control and Prevention, the 1994 prevalence rate of lead poisoning in Boston was 9.2%. This is higher than the national rate derived from NHANES III data of 4.2% (U.S. Department of Health, 1997b, 1998). It is interesting to note that neither the child's blood lead level, nor a binary variable indicating elevated blood lead levels were significant in any of the four models. Although lead can affect many factors including a child's ability to grow and learn, it is not clear the symptoms would be obvious enough for a doctor to rank a child with lead poisoning as less healthy than one without lead poisoning.

Another possible explanation for the apparent lower level of health could be a result of the pseudo strata selected in the Northeast. The data are only designed to represent the country as a whole; the persons selected within a given region may not be representative of the region. It could be that the pseudo strata selected in the Northeast have a higher concentration of less healthy children than other parts of the Northeast. Clearly the possible regional effects require further study with other data sets.

Conclusions

This research used a household model to study the impact of the WIC Program and other factors on the health of U.S. preschool children. The data were from the third National Health and Nutrition Examination Survey. Ordered probit equations were estimated for the physician's overall evaluation of the child's health. The empirical results suggest some important policy implications related to determinants of child health which government policies and programs can influence.

The direct impact of income, as reflected in the poverty income ratio, is surprisingly small. An increase in income that takes a household from the poverty level to twice that level, would increase the child's chances of being in excellent health by only three to ten percentage points. The higher end of this range was calculated using children who live in households below 185% of the poverty line. However, the higher income might be likely to have a number of indirect effects which benefit child health. The regional effects are relatively large, positive for the Midwest, South and West compared to the Northeast. This result is puzzling, and could be a result of sample selection or an actual effect from pollution (including lead poisoning), population density, climate, or other factors. The regional variables should be examined in other data sets to confirm the result.

The most important finding of this analysis relates to the very substantial beneficial impact of the WIC Program on child health. Children in households participating in WIC are five to eleven percentage points more likely to be in excellent health, ceteris paribus, with the effect being stronger in the WIC eligible sample. The consistency and magnitude of these effects provide strong evidence in support of this program. The WIC Program is more effective at improving child health compared to even large increases in household income. Moreover, the beneficial effect of WIC on health is greatest for children in the poorer households which are eligible for the program.

[Received January 2001; final revision received September 2002.]

References

Alaimo, K., C. Olson and E.A. Frongillo. "Food Insufficiency and American School-Aged Children's Cognitive, Academic, and Psychosocial Development." *Pediatrics* 108(2001):44–54.

Arcia, G.T., L.A. Crouch and R.A. Kulka. "Impact of the WIC Program on Food Expenditures." *American Journal of Agricultural Economics* 72(1990):218–26.

Ball, T. and A.L. Wright. "Health Care Costs of Formula-Feeding in the First Year of Life." *Pediatrics* 103(1999):870–76.

Basiotis, P.P., C.S. Kramer-LeBlanc and E.T. Kennedy. "Maintaining Nutrition Security and Diet Quality: The Role of the Food Stamp Program and WIC." *Family Economics and Nutrition Review* 11(1998):4–16.

Basiotis, P.P., S.R. Johnson, K. Morgan and A. Chen. "Food Stamps, Food Costs, Nutrient Availability, and Nutrient Intake." *Journal of Policy Modeling* 9(1987):383–404.

Beaudry, M., R. Dufour and S. Marcoux. "Relation Between Infant Feeding and Infections During the First Six Months of Life." *Journal of Pediatrics* 126(1995):191–97.

Becker, G. "A Theory of the Allocation of Time." *The Economic Journal* 75(1965):493–517.

Behrman, J. and A. Deolalikar. "Health and Nutrition." In H. Chenery and T.N. Srinivasan, eds. *Handbook of Development Economics*. New York: Elsevier Science Publisher, 1988, pp. 631–711.

Blank, R. *It Takes a Nation: A New Agenda for Fighting Poverty*. Princeton NJ: Princeton University Press, 1997.

Blank, R. and P. Ruggles. "When Do Women Use Aid to Families with Dependent Children and Food Stamps? The Dynamics of Eligibility Versus Participation." *The Journal of Human Resources* 31(1995):57–89.

Brown, J. and P. Tieman. "Effect of Income and WIC on the Dietary Intake of Preschoolers: Results of a Preliminary Study." *Journal of the American Dietetic Association* 86(1986):1189–91.

Buescher, P., L. Larson, M.D. Nelson and A. Lenihan. "Prenatal WIC Participation Can Reduce Low Birth Weight and Newborn Medical Costs: A Cost-Benefit Analysis of WIC Participation in North Carolina." *Journal of the American Dietetic Association* 93(1993):163–66.

Corman, H., T. Joyce and M. Grossman. "Birth Outcome Production Function in the U.S." *Journal of Human Resources* 22(1987):339–60.

Cushing, A., J. Samet, W. Lambert, B. Skipper, W. Hunt, S. Young and L. McLaren. "Breast-Feeding Reduces Risk of Respiratory Illness in Infants." *American Journal of Epidemiology* 147(1998):863–70.

Devaney, B., L. Bilheimer and T. Schore. "Medicaid Costs and Birth Outcomes: The Effects of Prenatal WIC Participation and the Use of Prenatal Care." *Journal of Policy Analysis and Management* 11(1992):573–92.

Federal Interagency Forum on Child and Family Statistics. *America's Children: Key National Indicators of Well-Being 2001*. Washington DC: Forum on Child and Family Statistics, Government Printing Office, 2001.

General Accounting Office, Human Resources Division (GAO). "Early Intervention: Federal Investments Like WIC Can Produce Savings." GAO/HRD-92-18, April 1992.

Greene, W.H. *Econometric Analysis*, 3rd ed. New York: Prentice-Hall, 1997.

Hutchins, S., J. Rosenthal, P. Eason, E. Swint, H. Guerrero and S. Hadler. "Effectiveness and Cost-Effectiveness of Linking the Special Supplemental Program for Women, Infants, and Children (WIC) and Immunization Activities." *Journal of Public Health Policy* 20(1999):408–26.

Kramer-LeBlanc, C., A. Mardis, S. Gerrior and N. Gaston. *Review of the Nutritional Status of WIC Participants*. Washington DC: U.S. Department of Agriculture, Center for Nutrition Policy and Promotion, CNPP Report 8, August 1999.

Oliveira, V. and C. Gundersen. *WIC and the Nutrient Intake of Children*. Washington DC: U.S. Department of Agriculture, Food and Rural Economics Division, Economic Research Service, Food Assistance and Nutrition Research Report 5, 2000.

Owen, A.L. and G.M. Owen. "Twenty Years of WIC: A Review of Some Effects of the Program." *Journal of the American Dietetic Association* 97(1997):777–82.

Pehrsson, P.R., P.B. Moser-Veillon, L.S. Sims, C.W. Suitor and E. Russek-Cohen. "Postpartum Iron Status in Nonlactating Participants and Nonparticipants in the Special Supplemental Nutrition Program for Women, Infants and

Children." *American Journal of Clinical Nutrition* 73(2001):86–92.

Rose, D., J.P. Habicht and B. Devaney. "Household Participation in the Food Stamp and WIC Programs Increases the Nutrient Intakes of Preschool Children." *The Journal of Nutrition* 128(1998):548–55.

Rosenzweig, M. and T.P. Schultz. "Estimating a Household Production Function: Heterogeneity, the Demand for Health Inputs, and Their Effects on Birth Weight." *Journal of Political Economy* 91(1983):723–46.

Senauer, B. and M. Garcia. "Determinants of the Nutrition and Health Status of Preschool Children: An Analysis with Longitudinal Data." *Economic Development and Cultural Change* 39(1991):371–90.

Shefer, A. and M. Massoudi. "Missed Opportunities to Improve Immunization Status Among High-Risk Children in the WIC Program." *Journal of Public Health Management Practice* 5(1999):82–85.

Stata Corporation. *Stata Reference Manual*, Release 6 ed. College Station, TX: Stata Press, 1999.

Strauss, J. and D. Thomas. "Health, Nutrition, and Economic Development." *Journal of Economic Literature* 36(1998):766–817.

U.S. Census Bureau. *Statistical Abstract of the United States, 1999*. Washington DC, 2001.

U.S. Department of Agriculture, Food and Nutrition Service (USDA FNS). "WIC Program Participation and Costs." Website www.fns.usda.gov/pd.wisummary.htm, data accessed on 27 March 2002.

U.S. Department of Health and Human Services and National Centers for Disease Control and Prevention. *Plan and Operation of the Third National Health and Nutrition Examination Survey, 1988–94*. Washington DC, 1994.

——. "Nutritional Status of Children Participating in the Special Supplemental Nutrition Program for Women, Infants, and Children—United States, 1988–1991." *Morbidity and Mortality Weekly Report* 45(1996):65–69.

——. *National Health and Nutrition Examination Survey, III, 1988–94*. Washington DC, October 1997a.

——. "Update: Blood Lead Levels—United States, 1991–1994." *Morbidity and Mortality Weekly Report* 46(1997b):141–46.

——. "Recommendations to Prevent and Control Iron Deficiency in the United States." *Morbidity and Mortality Weekly Report* 47(1998):1–36.

Variyam, J. "WIC Participation and the Nutrient Intake of Preschoolers." Paper presented at AAEA annual meeting, Chicago IL, 5–8 August 2001.

Variyam, J., J. Blaylock and B. H. Lin. "Mother's Nutrition Knowledge and the Diet Quality of Preschool Children." Paper Presented at USDA S-278 Working Group Meeting, St. Louis MS, October 1998.

Wilde, P., P. McNamara and C. Ranney. "The Effect of Income and Food Programs on Dietary Quality: A Seemingly Unrelated Regression Analysis with Error Components." *American Journal of Agricultural Economics* 81(1999):959–71.

Wolfe, B. and J. Sears. "Health Indicators for Preschool Children Ages One to Four." In R.M. Hauser, B.V. Brown and W.R. Prosser, eds. *Indicators of Children's Well-Being*. New York: Russell Sage Foundation, 1997, pp. 76–94.